<u>UNITED STATES SPECIFICATION</u>

TO ALL WHOM IT MAY CONCERN:

BE IT KNOWN that I, Heinz Lindenmeier a citizen of Germany, having an address of Fürstenrieder Str. 7b, 82152 Planegg, Germany, have invented certain new and useful improvements in

AN ANTENNA HAVING A MONOPOLE DESIGN,
FOR USE IN SEVERAL WIRELESS COMMUNICATION SERVICES

of which the following is a specification.

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to an antenna having a monopole design for at least two wireless communication services consisting of a monopole element 10, structured essentially along a straight line 11.

2. The Prior Art

Monopole antennas for several wireless communication services are known, for example, from *U.S. Patent 6,653,982 B2*. There, the block diagram of an antenna for several wireless communication services is indicated in Fig. 21b. The radiator of the vertical antenna conductor is selected to be sufficiently large for the wireless communication service having the lowest frequency. For the case of a required frequency-selective shortening of the electrically effective wave length for higher wireless channel frequencies, interruption points are inserted in the vertical antenna conductor, i.e. suitable dummy elements to configure the vertical diagram and the foot point impedance. In many cases, however, it is advantageous to select the radiator length so that it is not sufficiently large for the lowest

frequency range, but rather uses shortened radiators for several wireless communication services. An antenna having a desired low structural shape for several wireless communication services is indicated in *U.S. Patent 6,218,997 B1*. This antenna has the disadvantage that because of its shape, which deviates from rotational symmetry, it does not possess a sufficient omnidirectional directional diagram, in terms of azimuth. Furthermore, because of its structural shape, it cannot be used as a communication antenna for several communication services, as shown in *U.S. Patent 6*,653,982, with the antenna for satellite reception indicated there.

SUMMARY OF THE INVENTION

It is an object of the present invention to provide an antenna, which has a small structural height, while having rotation symmetry properties, and possesses the directional diagram of an electrically short monopole antenna, in the various frequency ranges of the predetermined wireless communication services, and moreover, has an antenna impedance that is advantageous for the impedance adjustment, in each instance.

BRIEF DESCRIPTION OF THE DRAWINGS

Other objects and features of the present invention will become apparent from the following detailed description considered in connection with the accompanying drawings. It is to be understood, however, that the drawings are designed as an illustration only and not as a definition of the limits of the invention.

In the drawings, wherein similar reference characters denote similar elements throughout the several views:

Fig. 1 shows a monopole antenna above a conductive base area in accordance with the present invention;

Fig. 2 shows an antenna in which the inside radius of the innermost ring structure is selected to approach zero;

Fig. 3 shows an antenna for use in communication services for two frequency ranges;

Fig. 4 shows the reactance circuits of FIG. 3 configured in an advantageous manner for a combined coverage of several communication services in one antenna;

Fig. 5 shows an antenna with a square shaped closed area as the innermost ring structure, and a square shaped outer ring structure;

Fig. 6a shows a horizontal diagram of an antenna

embodiment according to the invention, for the antenna of Fig. 5, at 2300 MHz;

Fig 6b shows a vertical directional diagram of the antenna of Fig. 5 at 2200 MHz;

Fig 6c shows a vertical directional diagram of the antenna of Fig. 5 at 960 MHz;

Fig. 7 shows the impedance diagram of the antenna of Fig. 5;

Figs. 8a and 8b show three frequency ranges with respect to the reactances for the associated reactance circuits; and

Figs. 8a', 8a", and 8b', 8b" show possible reactance circuits for an antenna of Fig. 2, for three frequency ranges with the frequencies that are fed to them with f_3 as the lowest, and f_1 as the higher frequency.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now in detail to the drawings and, in particular, Fig. 1, a monopole antenna is shown disposed above a conductive base area 9 in accordance with the present invention. In the present example, the roof capacitor 1 consists of two ring structures 2, arranged concentric to one another. The monopole element 10 is connected with an inner

ring structure 2' at its top end, by way of reactance circuits 4. The outer ring structure 2 is connected with the inner ring structure 2' by way of other reactance circuits 4. It is advantageous if the reactance circuits 4 are represented by dummy elements 8, the reactance X(f) of which is configured so that the reactance circuits 4 that connect outer ring structure 2 with inner ring structure 2' are accordingly at high impedance in the frequency range of the wireless communication service having the higher frequency, so that outer ring structure 2 is ineffective, to a great extent. In the frequency range of the wireless communication service having the lower frequency, all of the reactance circuits shown in Fig. 1 are sufficiently at low impedance. By means of the arrangement shown, it can be assured, if the outside dimensions 7 of the ring structures 2 and 2' are suitably selected, that the vertical diagram of the monopole antenna, having a roof capacitor 1 in both frequency ranges, corresponds to that of an electrically small radiator. Furthermore, by suitably selecting reactance circuits 4, it can be assured that the impedance at the foot point of the monopole is almost real or non-reactive in both frequency ranges, and that an adjustment can be easily produced.

Depending on the demands on the rotational symmetry of the directional diagrams, reactance circuits 4 are divided up into several individual circuits composed of dummy elements 8, which are uniformly distributed over the circumference of ring structures 2, in an advantageous embodiment of the proposed invention.

In Fig. 2, the inside radius of the innermost ring structure 2 is selected approaching zero, so that innermost ring structure 2 becomes a circular closed area 5. In the form shown, with two additional ring structures 2, 2' and 2", it is possible, according to the invention, to design the antenna for three frequency ranges, so that it works as an electrically short antenna for all three frequency ranges.

An antenna for wireless communication services for two frequency ranges is shown in similar manner in Fig. 3. In the case of a combined coverage of several telephone services in one antenna according to the AMPS/GSM900 standard in a first frequency range of 824 MHz, to 960 MHz and the GSM1800/PCS/UMTS standard in a second frequency range between 1710 MHz and 2170 MHz, reactance circuits 4 in Fig. 3 are configured in advantageous manner as indicated in Fig. 4.

The circuit indicated there, composed of dummy elements 8, can be divided up into four reactance circuits 4, for example, so that the reactances shown must be selected to be four times as high in ohms in each individual circuit. This antenna can therefore be used instead of the radiator 20 in Fig. 22 of *U.S. Patent 6,653,982 B2*, in advantageous manner, because of the given rotational symmetry of the total arrangement, which is a prerequisite for the combination of the satellite function antenna indicated there.

In the case of a radiator shape according to the invention, the condition of rotational symmetry is fulfilled even if ring structures 2 deviate from a circular structure. This is because of the outside dimension 7 of individual ring structures 2, (which is small in comparison with the wavelength), in combination with the lack of effect of the outer ring structures 2, which are shut off at higher frequencies. This antenna, which is configured, as shown in Fig. 5, with a closed area 5 in square shape as the innermost ring structure 2, and an outer ring structure 2 structured in square shape, has an azimuthal directional diagram, which as shown in Fig. 6a. At this frequency, the outside dimension 7 corresponds to a relative length of 5. It turns out, in

surprising manner, that because of the high impedance of the reaction circuit 4 in Fig. 5 at the higher frequency, the outer ring structure 2 does not distort the azimuthal diagram. Likewise, it is evident from Fig. 6b and 6c that the vertical diagrams in both frequency ranges correspond to those of an electrically short monopole. In Fig. 7, the impedances for both frequency ranges are marked, and show values for which an impedance adjustment can be made in simple manner.

In order to configure the capacitative coupling between the ring structures 2 in a sufficiently advantageous manner, gap width 6 should be selected to be sufficiently large. On the other hand, however, it should be selected not to be so large, that the spatial capacitance of the remaining area of ring structures 2 is not too small.

Figs. 8a and 8b show three frequency ranges with respect to the reactances for the associated reactance circuits 4, and Fig. 8a′, 8a″ and 8b′, 8b″ show possible reactance circuits 4 for an antenna according to Fig. 2, for three frequency ranges for the frequencies to be received by them, wherein f_3 is the lowest, and f_1 is the higher frequency.

Here, Fig. 8a shows the frequency progression of the reactance X1(f) for reactance circuits 4 that are switched between the inner closed area 5 and the subsequent ring structure 2, having low impedance values in the ranges of frequencies 2 and 3, and high impedance values in the highest frequency range 1, to separate the outermost ring structure 2. Analogous to this, Fig. 8b shows the frequency progression of the reactance X2(f) for reactance circuit 4 of Figs. 8b′ and 8b″ switched between the outermost and the next inner ring structure 2', having low impedance values in the frequency range f_3 and high impedance values in the higher frequency ranges f_2 and f_1, to separate two outer ring structures.

Accordingly, while only a few embodiments of the present invention have been shown and described, it is obvious that many changes and modifications may be made thereunto without departing from the spirit and scope of the invention.